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Description

METHOD AND APPARATUS FOR INTERWORKING BETWEEN INTERNET PROTOCOL (IP) TELEPHONY PROTOCOLS

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Priority Application

This Application claims the benefit of U.S. Provisional Patent Application Serial No. 60/137,867 filed June 7, 1999, the disclosure of which is incorporated herein by reference in its entirety.

10

Technical Field

The present invention relates to a method and an apparatus for interworking between communications protocols. More particularly, the present invention relates to a method and an apparatus for interworking
15 between internet protocol (IP) telephony protocols.

Background Art

There are a variety of known protocols for establishing media stream communications, such as voice, data, video, or combinations thereof, over
20 an IP network. Protocols for establishing media stream communications over an IP network are referred to herein as IP telephony protocols. One example of an IP telephony protocol is the media gateway control protocol (MGCP). MGCP defines signals and events by which a software entity,

Figure 1 illustrates conventional communications using MGCP. In Figure 1, MGC **100** receives call signaling information from SGs **102** and **103** and controls MGs **104** and **105** to establish packetized media stream communications between end users in packet network **106**. For example, SG **102** and MG **104** can be associated with a calling party end user device for a given media stream communication. Similarly, SG **103** and MG **105** can be associated with a called party end user device for a given media stream communication. MGC **100** can control MGs **104** and **105** to establish media stream communications between the called and calling end user devices, such as PSTN terminals.

A detailed explanation of MGCP is found in Media Gateway Control Protocol (MGCP), Version 0.1 Draft, Internet Engineering Task Force, February 21, 1999, the disclosure of which is incorporated herein by reference in its entirety.

Figure 2 illustrates an example of conventional H.323 communications. In Figure 2, a first gateway **200** can be associated with a calling end user device and a second gateway **202** can be associated with a called end user device for a given media communication. Gatekeeper **204** performs call signaling functions, such as call setup and teardown, to establish calls between end user devices associated with gateways **200** and **202**. The end user devices can be PTSN terminals connected to gateway **200**. Alternatively, gateway **200** can be omitted and replaced by H.323 terminals or H.323 MCUs. Once gatekeeper **204** performs the call signaling functions necessary to set up a call, the media stream for the call flows between gateways **200** and **202**. Detailed information relating to H.323 can be found in ITU Recommendation H.323, Packet Based Multimedia Communications Systems, February 1998, the disclosure of which is incorporated herein by reference in its entirety.

25 incorporated herein by reference in its entirety.

Yet another IP telephony protocol is ITU Recommendation H.248. The Internet Engineering Task Force (IETF) formed the MEGACO Group to evolve the MGCP protocol. As the MEGACO Group matured the protocol, the MEGACO Group allied itself with the ITU, and the specification
5 developed by the MEGACO Group has become known as ITU Recommendation H.248. Thus, ITU recommendation H.248 can be viewed similarly to MGCP.

Another IP telephony protocol is the session initiation protocol (SIP). SIP is an application layer signaling protocol for creating, modifying, and
10 terminating sessions between one or more participants. The sessions include internet multimedia conferences, internet telephone calls, and multimedia distribution. SIP originated from Columbia University and is gaining acceptance as a protocol for exchanging call signaling information over a packet network. A detailed description of SIP can be found in
15 Request for Comments (RFC) 2543 SIP: Session Initiation Protocol, March 1999, the disclosure of which is incorporated herein by reference in its entirety.

In addition to the published protocols described above, many vendors of telecommunications equipment and services are supporting IP telephony
20 applications via proprietary protocols.

All of the IP telephony protocols described above are being implemented by various vendors. However, standards for interworking equipment that communicates using one protocol with equipment that communicates using another protocol are immature, nonexistent, or focus
25 only on a specific type of application. Accordingly, there exists a long-felt

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Many of the protocols described herein define an entity that is responsible for performing functions and requests on behalf of a telephony device. Typically, these functions and requests include translations, media capabilities exchange, and other services. The entities that perform the functions can be logical, physical, or both. For example, in MGCP, the MGC or call agent performs call signaling functions on behalf of a gateway. In H.323, the gatekeeper performs call signaling functions for an H.323 gateway. In SIP, a proxy server performs call signaling functions for an end user. In order to facilitate a description of the present invention, the term call server is used herein to refer to an entity that performs call signaling functions, such as translations and media capabilities exchange, on behalf of an end user device, gateway, or other entity.

According to a first aspect, the present invention includes a call server including a first protocol agent and a second protocol agent. The first protocol agent communicates with a first protocol device according to a first protocol. The second protocol agent communicates with a second protocol

device according to a second protocol. An interworking agent provides functions usable by the first and second protocol agents to communicate using a third protocol. The third protocol provides a superset of the functions provided by the first and second protocols.

5 Accordingly, it is an object of the present invention to provide a novel method and apparatus for interworking between IP telephony protocols.

An object of the invention having been stated hereinabove, and which is achieved in whole or in part by the present invention, other objects will be evident as the description proceeds, when taken in connection with the
10 accompanying drawings as best described hereinbelow.

Brief Description of the Drawings

A description of the present invention will now proceed with reference to the accompanying drawing of which:

15 Figure 1 is a block diagram illustrating conventional MGCP network entities;

Figure 2 is a block diagram illustrating conventional H.323 network entities;

Figure 3 is a block diagram illustrating media gateway controller and
20 gatekeeper functions implemented within a call server according to an embodiment of the present invention;

Figure 4 is a block diagram illustrating a call server wherein each call half is represented by an agent according to an embodiment of the present invention;

Figure 5 is a block diagram illustrating a call server including a plurality of interworking agents according to an embodiment of the present invention;

Figure 6 is a block diagram illustrating protocol agents implementing
5 originating and terminating call half functions executing on different machines wherein an interworking agent is associated with each protocol agent;

Figure 7 is a block diagram illustrating a call server including MGCP, interworking, and H.323 agents for interworking MGCP and H.323 entities
10 according to an embodiment of the present invention;

Figure 8 is a block diagram illustrating a connection information parameter data structure according to an embodiment of the present invention;

Figures 9(a) and 9(b) are flow charts illustrating message tunneling
15 according to an embodiment of the present invention;

Figure 10 is a block diagram illustrating exemplary agent interworking protocol message structures according to an embodiment of the present invention;

Figure 11 is a block diagram illustrating an exemplary data structure
20 for a digit information parameter according to an embodiment of the present invention;

Figure 12 is a call flow diagram illustrating exemplary call signaling for H.323 fast start to MGCP communications according to an embodiment of the present invention;

Figure 13 is a call flow diagram illustrating H.323 non-fast-start to MGCP communications according to an embodiment of the present invention;

Figure 14 is a call flow diagram illustrating exemplary call signaling for
5 a hold scenario between H.323 and North American Q.931 endpoints according to an embodiment of the present invention;

Figure 15 is a call flow diagram illustrating exemplary call signaling for a retrieve scenario between H.323 and North American Q.931 endpoints according to an embodiment of the present invention;

10 Figure 16 is a call flow diagram illustrating exemplary call signaling for a hold scenario between H.323 and MGCP endpoints according to an embodiment of the present invention;

Figure 17 is a call flow diagram illustrating exemplary call signaling for a retrieve scenario between H.323 and MGCP endpoints according to an
15 embodiment of the present invention;

Figure 18 is a call flow diagram illustrating exemplary call signaling between H.323 and MGCP endpoints for common channel signaling according to an embodiment of the present invention; and

Figure 19 is a call flow diagram illustrating exemplary call signaling
20 between an MGCP gateway and an H.323 gateway according to an embodiment of the present invention.

Detailed Description of the Invention

The present invention provides a novel method and apparatus for
25 interworking between IP telephony protocols. In order to provide this

interworking, a call server includes agents that communicate with other entities according to the protocols implemented by the other entities. However, the protocol agents communicate with each other utilizing a protocol-independent agent interworking protocol (AIP). As a result, network
5 entities that implement different protocols can seamlessly communicate with each other.

Figure 3 illustrates a call server including MGC and GK functions according to an embodiment of the present invention. In Figure 3, a call server **300** includes an MGC function **302** and a GK function **303**. The call
10 server is a software entity that can execute on a single machine or on multiple machines. MGs and SGs recognize call server **300** as an MGC. H.323 endpoints, such as gateways, recognize call server **300** as a GK. For example, in the illustrated embodiment, ingress MG **304**, egress MG **306**, and SG **308** recognize call server **300** as an MGC. Similarly, ingress H.323
15 gateway **310** and egress H.323 gateway **312** recognize call server **300** as a gatekeeper.

In order for MGs **304** and **306** to recognize call server **300** as an MGC, MGC function **302** in call server **300** is adapted to communicate with MGs **304** and **306** using MGCP. Similarly, in order for SG **308** to recognize
20 call server **300** as an MGC, MGC function **302** in call server **300** communicates with SG **308** using a call signaling protocol, such as ISDN Part (ISUP). In order for H.323 gateways **310** and **312** to recognize call server **300** as a gatekeeper, gatekeeper function **303** in call server **300** communicates with gateways **310** and **312** according to ITU
25 Recommendations H.225 and H.245.

Figure 4 illustrates an embodiment of call server **300** in which the call processing functions illustrated in Figure 3 are separated into call agents, each of which performs call half functions. As used herein, call half functions refer to functions associated with either the originating or terminating side of a call. For example, in Figure 4, MGCP function **302** illustrated in Figure 3 is divided into MGCP agent **302A** and MGCP agent **302B**. Similarly, H.323 function **303** illustrated in Figure 3 is divided into H.323 agent **303A** and H.323 agent **303B**. MGCP agent **302A** and H.323 agent **303A** can perform call originating functions, such as collection of digits and translations. MGCP agent **302B** and H.323 agent **303B** can perform call terminating functions, such as trunk selection and alerting the called party of an incoming call. The functions performed by each call half will be explained in detail below with reference to call flow diagrams.

As mentioned above, the present invention is not limited to interworking between MGCP and H.323 entities. For example, Figure 5 illustrates a call server including protocol agents configured to communicate with other agents using a variety of different protocols. In the illustrated embodiment, call server **300** includes MGCP agents **302A** and **302B** for processing MGCP to MGCP calls, H.323 agents **303A** and **303B** for processing H.323 to H323 calls, H.323 agent **500A** and MGCP agent **500B** for processing H.323 to MGCP calls, H.323 agent **502A** and SIP agent **502B** for processing H.323 to SIP calls, and H.323 agent **504A** and NAQ.931 agents **504B** for processing H.323 to NAQ.931 calls. In addition, to the protocol agents, call server **300** also includes an interworking agent **506** which facilitates communication between protocol agents. More particularly,

interworking agent **506** includes methods for getting and setting AIP parameters, building AIP messages, and establishing and maintaining connections, such as TCP or reliable UDP connections, between protocol agents. Interworking agents can also identify AIP message types, which will
5 be described in more detail below. Thus, as illustrated in Figure 5, interworking agent **506** provides functions usable by a variety of different protocol agents to provide seamless interworking between the protocol agents.

In a preferred embodiment of the invention, the interworking agent is
10 divided into separate software components, one component associated with the protocol agent for each call half. The division of the interworking agent into two software components allows protocol agents associated with a given call to execute on separate machines.

Referring to Figure 6, call server **300** illustrated in Figure 5 is divided
15 into call servers **300A**, **300B**, and **300C**, which can execute on the same machine or on different machines. Call server **300A** includes protocol agents that perform both originating and terminating call half functions. Call servers **300B** and **300C** each include protocol agents that perform only originating or terminating call half functions. This division of call processing functionality is
20 enabled by interworking agents components **506A** and **506B**, which enable protocol agents to communicate with each other using AIP messaging. Exemplary information that can be exchanged using AIP messaging includes information regarding call progress, media capabilities and addresses, supplementary services, etc. By allowing the protocol agents to reside on

separate machines, the interworking agents according to embodiments of the present invention allow efficient division of call processing functions.

Figure 7 illustrates an example of an MGCP-H.323 network typology wherein communication between MGCP and H.323 endpoints occurs through a call server according to an embodiment of the present invention. In Figure 7, call server **300** includes MGCP agent **700A** for performing originating call half functions according to the media gateway control protocol and H.323 agent **700B** for performing terminating call half functions according to the H.323 protocol. More particularly, MGCP agent **700A** communicates with ingress media gateway **304** according to the media gateway control protocol and with signaling gateway **306** according to a call signaling protocol, such as ISUP. H.323 agent **700B** communicates with H.323 gateway **312** according to H.225 and H.245 protocols. MGCP agent **700A** and H.323 agent **700B** communicate with each other using AIP messaging. Interworking agent components **702A** and **702B** provide the functions that protocol agents **700A** and **700B** use to formulate and process AIP messages.

Because the interworking agent components **702A** and **702B** provide functions for converting messages to and from a protocol independent format, MGCP agent **700A** and the H.323 agent **700B** need not be aware of each other's protocol. Similarly, MG **304** and SG **306** need not be aware of the protocol of H.323 gateway **312**, and H.323 gateway **312** need not be aware of the protocol of MG **304** and SG **306**.

Agent Interworking Protocol

As stated above, interworking agents according to embodiments of the present invention communicate with each other according to a protocol independent format referred to as the agent interworking protocol. The agent interworking protocol is preferably capable of representing a reasonable superset of the messaging capabilities of all protocols to be supported within the packet network. Designing an interworking protocol that supports all of the capabilities of all of the supported protocols is an unnecessarily burdensome task since some capabilities are rarely used or are only useful when communicating between devices that support the particular protocol. In addition, these rarely used capabilities can be communicated between agents that support these capabilities using tunneling, as will be described in more detail below. Accordingly, it is desirable that the agent interworking protocol provide a reasonable superset of the capabilities of supported protocols.

Rather than designing an entirely new protocol for use as the agent interworking protocol, it is more desirable to select an existing protocol that comes close to meeting the superset definition described above and extending that protocol. Existing protocols that could be used as the base protocol for the agent interworking protocol include Q.931, ISUP, and SIP. The agent interworking protocol implemented in interworking agents according to preferred embodiments of the present invention is based upon ISUP. For example, AIP includes traditional ISUP messages such as initial address messages (IAM), answer messages (ANM), and release messages (REL). The agent interworking protocol extends the base protocol to include

additional procedures and signaling required to meet interoperability requirements. The functions and data structures used in the agent interworking protocol to meet these requirements will now be discussed in more detail.

- 5 One function that must be provided by the agent interworking protocol is a method for exchanging media capabilities between protocol agents. Each of the agent protocols to be interworked provide some means by which a telephony device can make known the media capabilities that it supports. These capabilities must be exchanged between two devices that desire to
- 10 participate in a media stream communication in order to select a mutually compatible media session definition.

Capabilities Exchange Between H.323 Devices

- H.323 allows an endpoint to advertise its capabilities at two different times - during call establishment and after call establishment. For example,
- 15 some H.323 devices support fast start capabilities which allow a partial list of media capabilities to be exchanged in H.225 call establishment messages. This method of exchanging capabilities allows faster establishment of a media stream between endpoints because capabilities are exchanged during call signaling, rather than waiting until after call signaling has been
- 20 completed. In order to exchange capabilities after call establishment, H.323 compliant devices use H.245 signaling to provide a full description of all media capabilities supported.

Capabilities Exchange Between MGCP and SIP Devices

- MGCP and SIP support the use of the session description protocol
- 25 (SDP) for encoding the capabilities supported by the device. The session

description protocol is included in call establishment messages similarly to H.323 fast start messages. For example, a SIP call establishment message, such as an INVITE message, includes an SDP portion in the body of the message. The SDP portion includes the capabilities supported by the
5 endpoint, such as encoding and decoding algorithms, type of media stream, etc.

Because these capabilities can be exchanged during call setup or after call establishment, the agent interworking protocol implemented in call servers according to embodiments of the present invention is preferably
10 flexible enough to support capabilities exchange at either time. In addition, because each of the above-mentioned protocols uses different syntax for specifying the capability's definition, AIP preferably provides a normalized syntax to which interworking agents can map the capability's definitions.

Media Management

15 In addition to providing a method for exchanging media capabilities, the agent interworking protocol preferably also provides media management capabilities that include a reasonable superset of the media management capabilities of supported protocols. For example, each of the agent protocols provide support for establishing and altering media streams;
20 however, the specific protocols vary significantly. H.323 fast start procedures allow H.323 devices to establish a media stream in concert with call establishment. However, fast start is optional and might not be supported by a given H.323 device. H.245 procedures allow H.323 devices to open and close media channels post call establishment. H.323 is very
25 limited in its ability to alter a media stream once established. H.323 media

streams can be unidirectional or bi-directional. Voice/audio media is typically represented via two independent unidirectional streams on IP networks with bi-directional media being typically used for data or for voice on ATM networks.

5 MGCP supports establishment of media streams during call establishment similar to H.323 fast start procedures. Media streams can be either unidirectional or bi-directional and can be changed from one format to the other at any time during a call. MGCP allows media channels to be modified in a variety of ways without having to be closed. For example, a
10 media stream can be redirected by changing the receiving real time protocol (RTP) address. The encoding format can be changed by changing the codec. The mode can be changed to send only, send receive, receive only, or inactive. SIP is similar to MGCP in its ability to modify media streams.

 In order to provide an interworking solution that accommodates these
15 agent protocols, three design objectives are preferably met. The first design objective is that the agent interworking protocols must provide sufficient flexibility to meet the requirements of all agent protocols. Second, the agent design preferably maps between agent specific and AIP procedures and syntax for media management. The third objective is that a flexible control
20 framework is preferably implemented that allows the agent to easily react to media changes made by the agent implementing the other call half. The connection information parameter illustrated in Figure 8 is the mechanism provided by the agent interworking protocol for implementing media management functions and exchanging media capabilities. The times for
25 exchanging media capabilities and performing media management functions

according to the agent interworking protocol will be described in more detail below with respect to the call flow diagrams.

Figure 8 is a table illustrating exemplary fields and field values for the connection information parameter according to an embodiment of the present invention. In Figure 8, the left hand column represents the fields in the connection information parameter data structure. The right hand column represents example values for each of the fields in the left hand column. In the illustrated embodiment, the connection information parameter includes a media type field **800** that holds a media type value **802** for specifying the type of media being exchanged or sought to be exchanged in a media stream. Example values for the media type field include audio, video, and data. Channel ID field **804** includes an internally assigned channel ID value that allows an interworking agent to identify the media stream. In the illustrated embodiment, 12345 is given as an example value **806** for channel ID field **804**. Channel operation field **808** includes a channel operation value **810** for specifying the operation being performed on the media stream. Values **810** for the channel operation field **808** are preferably a superset of protocol media stream operations for the supported protocols. In the illustrated embodiment, exemplary values for the channel operation field are no action, open, close, modify, mode change, redirect, direct, and send capabilities. The no action value indicates that no change is being made to the existing media stream. The open value specifies that a media stream is sought to be opened. The close value indicates that an open media stream is sought to be closed. The modify value indicates that the media stream is sought to be modified, e.g., changing a code^c from G.711 to G.729a. The

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added value for a call between two devices of the same type. In this case, the agent interworking protocol preferably supports tunneling of the native protocol message. As used herein, tunneling refers to transferring the native protocol message from one protocol agent to another protocol agent without
5 converting to and from the agent interworking protocol. The agent receiving the native protocol message can inspect the message, and if the agent understands the message, process the message accordingly.

An example of when it might be desirable to tunnel a message relates to H.323. H.323 provides a sophisticated means of representing terminal
10 capabilities in sets. The agent interworking protocol, as described herein, might not include functionality for representing terminal capabilities in sets as defined in H.323, because the other protocols do not support such capability. Another capability that H.323 supports which can not be supported by other protocols is the exchange of H.245 indications between two H.323 devices.
15 Some of these indications have no equivalent mapping to other agent protocols. In these situations, it can be desirable to tunnel the H.323 messages from one agent to another agent.

Method of Tunneling Messages

According to an embodiment of the present invention, interworking
20 messages can be of three types:

- Agent interworking protocol messages – protocol-neutral messages understood by all protocol agents;
- Native protocol messages – protocol-specific messages, such as SIP, MGCP, and H.323 messages;

- Multipart messages - messages that contain multiple other messages, such as native protocol messages and AIP messages. All agents are preferably capable of extracting the AIP message and processing the message accordingly. If the multipart message contains a native protocol message, this message is preferably processed if supported.

Figures 9(a) and 9(b) are flow charts illustrating exemplary formulating and processing of interworking messages by a call server according to an embodiment of the present invention. The flow chart in Figure 9(a) illustrates exemplary steps that can be performed by a sending protocol agent in formulating an interworking message using procedures provided by an associated interworking agent. The flow chart in Figure 9(b) illustrates exemplary steps that can be performed by a receiving protocol agent using procedures provided by an associated interworking agent upon receiving an interworking message. Referring to Figure 9(a), in step **ST1**, the sending protocol agent receives a message from an external entity, such as an H.323 gateway. In step **ST2**, the sending protocol agent determines whether a mapping is available to the agent interworking protocol. In step **ST3**, if a mapping is available, the sending protocol agent formulates the corresponding AIP message using functions provided by the interworking agent associated with the sending protocol agent (hereinafter, "the first interworking agent") and transmits the message to the receiving protocol agent (step **ST4**). In step **ST2**, if the sending protocol agent determines that the mapping to the agent interworking protocol is not available, the sending protocol agent simply transmits the protocol message without modification to the receiving protocol agent (step **ST4**). In step **ST2**, if the sending protocol

agent determines that a mapping to AIP is partially available, the sending protocol agent can formulate a multiprotocol message including the AIP message and the native protocol message (step **ST5**). The sending protocol agent can then transmit the multiprotocol message to the receiving protocol agent (step **ST4**).

Referring to Figure 9(b), in step **ST6**, the receiving protocol agent receives the message from the sending protocol agent. In step **ST7**, receiving protocol agent determines the message type, i.e., whether the message is a protocol specific message, an agent interworking protocol message, or a multipart message, using procedures provided by its associated interworking agent (hereinafter, "the second interworking agent"). In step **ST8**, if the receiving protocol agent determines that the message is an agent interworking protocol message, the receiving protocol agent processes the message (step **ST9**). In step **ST10**, the receiving protocol agent determines whether the message is a multipart message. If the message is a multipart message, the receiving protocol agent separates the multi-protocol message into its component messages (step **ST11**). After the receiving protocol agent separates the message, the receiving protocol agent reads the protocol specific portion of the AIP message (step **ST12**). In step **ST13**, the receiving protocol agent determines whether the protocol in the protocol specific portion is supported. If the protocol is not supported, the receiving protocol agent discards the message (step **ST14**). If the protocol is supported, the receiving protocol agent processes the message (step **ST15**). In step **ST16**, the receiving protocol agent processes the AIP portion of the message.

Referring to step **ST17**, if the receiving protocol agent determines that the message is a protocol specific message, the receiving protocol agent determines whether the protocol of the message is supported (step **ST18**). If the protocol is supported, the receiving protocol agent processes the message (step **ST19**). If the protocol is not supported, the receiving protocol agent discards the message (step **ST20**).

Transport Mechanism for Agent Interworking Messages

Interworking messages can be sent between protocol agents using any packet based protocol, for example, TCP, UDP, etc. In a preferred embodiment of the invention, interworking messages are transmitted between interworking agents using TCP over IP. As is known in the art, an IP message includes a header portion and a data portion. A TCP message is encapsulated in the data portion of the IP message. The TCP message also includes a header portion and a data portion. Interworking messages are encapsulated in the data portion of the TCP message. Interworking messages also include a header portion and a data portion. The header portion indicates the message type, i.e., AIP, protocol-specific, or multipart.

Figure 10 illustrates the relationships between IP messages, TCP messages, and interworking messages. In Figure 10, IP message **1000** includes a header portion **1002** and a data portion **1004**. TCP message **1006** is encapsulated in data portion **1004** of IP message **1000**. TCP message **1006** includes a header portion **1008** and a data portion **1010**. Interworking message **1012** is encapsulated in data portion **1010** of TCP message **1006**. Interworking message **1012** includes a header portion **1014** for indicating the message type and a data portion **1016** containing the

5 include one or more interworking messages **1012A** to **1012N**.

DTMF Digit Handling

15 change the duration of the tone sought to be transmitted. As a result, the
receiving application might not be able to correctly interpret the tone.

20 protocol (RTP) payload type that is exchanged between devices participating in the media stream. If this approach is standardized, various digital signal processor (DSP) manufacturers must comply with the standard before interworking will be accomplished. Because this involves a hardware change, much time can elapse before this occurs.

As a current solution to the problem, some of the agent protocols have implemented out-of-band techniques for handling DTMF digits. The agent interworking protocol according to embodiments of the present invention preferably provides a mapping to and from the out-of-band DTMF digit handling techniques of supported protocols. In order to provide a method for communicating DTMF information between protocol agents, the agent interworking protocol defines a data structure referred to herein as the digit information parameter. Figure 11 illustrates an exemplary digit information parameter data structure. In the illustrated embodiment, the digit information parameter data structure includes a digit field **1100** and a duration field **1102**. Digit field **1100** is capable of storing a digit value indicative of the DTMF digit being transmitted. For example, the digit field can contain a numerical value that indicates one of the keys on a telephone handset. Duration field **1102** stores a duration value for indicating the duration of the tone represented by the digit in the digit field. Specific examples of when the digit information parameter is exchanged will be explained below with reference to the call flow diagrams.

Interworking Examples

A. H.323 Fast Start to MGCP

Figure 12 is a call flow diagram illustrating exemplary call signaling performed by H.323 and MGCP agents including interworking agent capabilities according to an embodiment of the present invention. In Figure 12, H.323 endpoint **1200** is seeking to establish a call with an MGCP endpoint through MGCP gateway **1202**. MGCP gateway **1202** performs both signaling gateway and media gateway functions. H.323 agent **1204**

In line 1 of the call flow diagram, H.323 endpoint **1200** sends a
5 SETUP message to H.323 agent **1204**. The SETUP message includes fast
start parameters that specify suggested media options for the initial media
stream. In line 2 of the call flow diagram H.323 agent **1204** sends an agent
interworking protocol initial address message (IAM) to MGCP agent **1206**.
The AIP IAM message contains the media capabilities definition mapped
10 from the fast start parameters extracted from the SETUP message. In line 3
of the call flow diagram, MGCP agent **1206** sends an MGCP create
connection (CRCX) message to MGCP gateway **1202**. The CRCX message
contains local connection options that are mapped from the AIP media
capabilities information extracted from the IAM message into MGCP format.
15 In line 4 of the call flow diagram, MGCP gateway **1202** sends an OK
message to MGCP agent **1206**. The OK message includes a media
capability selected by MGCP gateway **1202** from the media capabilities
specified in the CRCX message. The media description for the selected
capability is returned in the SDP portion of the OK message.

20 In line 5 of the call flow diagram, MGCP agent **1206** sends an AIP call progress (CGP) message to H.323 agent **1204**. An AIP CPG message is used to signal events other than release and answer between protocol agents implementing different call halves. In the illustrated example, the CPG message includes a mapping of the SDP portion of the OK message

25 into AIP format. In addition, any other media capabilities which the MGCP

agent is capable of supporting can be included in the media description. In line 6 of the call flow diagram, H.323 agent **1204** transmits an ALERTING message to H.323 endpoint **1200**. H.323 agent **1204** maps the media description from the AIP CPG message into fast start parameters and
5 includes the fast start parameters in the ALERTING message. Any additional capabilities that were received by the H.323 agent are stored for later usage.

In line 7 of the call flow diagram, when the MGCP end user answers the call, signaling gateway **1202** sends a NOTIFY message to MGCP agent
10 **1206**. The NOTIFY message alerts MGCP agent **1206** of the off-hook event. In line 8 of the call flow diagram, in response to the NOTIFY message, MGCP agent **1206** transmits an AIP answer message (ANM) to H.323 agent **1204**.

In line 9 of the call flow diagram, in response to the answer message,
15 H.323 agent **1204** transmits a CONNECT message to H.323 endpoint **1200**. In lines 10 and 11 of the call flow diagram, H.323 endpoint **1200** and H.323 agent **1204** exchange master/slave and master/slave acknowledge messages. These messages are sent according to H.245 master/slave determination. This determination is made to resolve conflicts in media
20 formats. H.323 agent **1204** handles the exchange and does not map the exchange to the agent interworking protocol.

In line 12 of the call flow diagram, H.323 endpoint **1200** transmits an H.245 terminal capabilities set (TCS) message to H.323 agent **1204** to communicate the media capabilities of endpoint **1200** to H.323 agent **1204**.
25 In line 13, H.323 agent **1204** acknowledges the TCS message. In line 14 of

In lines 15 and 16 of the call flow diagram, H.323 endpoint **1200** and H.323 agent **1204** exchange TCS and TCS ACK messages. In this exchange, the capabilities of the other end, i.e., of MGCP gateway **1202**, which were received and stored upon receipt of the CPG message in line 5 of the call flow diagram, are sent to H.323 endpoint **1200** as an H.245 terminal capability set.

While Figure 12 illustrated H.323 to MGCP interworking for H.323 fast start procedures, Figure 13 illustrates H.323 to MGCP interworking without fast start procedures. In other words, in Figure 13, the H.323 media capabilities are not exchanged until after call establishment. The entities involved in communications in Figure 13 are the same as those illustrated in Figure 12. Thus, a description of these entities is not repeated herein.

Referring to Figure 13, in line 1 of the call flow diagram, H.323
25 endpoint **1200** sends a SETUP message to H.323 agent **1204**. The SETUP

message does not include fast start parameters. In line 2 of the call flow diagram, H.323 agent **1204** transmits an AIP IAM message to MGCP agent **1206**. The IAM message contains no media description. In other words, the connection information parameter is either not included or set to a null value.

- 5 In line 3 of the call flow diagram, MGCP agent **1206** transmits a CRCX message to MGCP gateway **1202**. The CRCX message can optionally contain a default set of media capabilities that do not reflect capabilities supported by the H.323 endpoint. A CRCX message example is as follows:

CRCX:

10

R: HD

L: Default media capabilities

M: Inactive (or receive only)

- 15 In the CRCX message example, the hd value in the R field instructs gateway **1202** to go off-hook. The value in the L field specifies local connection options, which indicate to gateway **1202** the media capabilities of H.323 endpoint **1200**. In response to the CRCX message, in line 4 of the call flow diagram, MGCP gateway **1202** transmits an OK message to MGCP agent **1206**. The OK message includes an SDP portion with the media description for the connection. An exemplary media description is as follows:

20

v=0

c=IP address

m=media description

- 25 In the exemplary media description set forth above, the IP address in the c= parameter is the IP address on MGCP gateway **1202** for receiving the media stream. The media description specified in the m= parameter includes the

In line 5 of the call flow diagram, MGCP agent **1206** transmits an AIP call progress (CPG) message to H.323 agent **1204**. The AIP CPG message includes the connection information parameter data structure in which the media description from the SDP portion of the AIP message is mapped into AIP format. The media description is stored by H.323 agent **1204**, but is not transmitted to H.323 endpoint **1200** as a fast start parameter.

20 In lines 12 and 13 of the call flow diagram H.323 endpoint **1200** and
H.323 agent **1204** exchange H.245 TCS and H.245 TCS ACK messages.
This exchange communicates the media capabilities of H.323 endpoint **1200**
to H.323 agent **1204**. In line 14 of the call flow diagram, H.323 agent **1204**
transmits a multipart message to MGCP agent **1206**. H.323 agent **1204**
25 maps the capabilities of H.323 endpoint **1200** into AIP format and includes

5 agent **1206** can only process the AIP portion of the multipart message.

15 endpoint **1200** returns its RTP port for each media stream in the
acknowledge messages.

20 the mode change to send receive. In line 22 of the call flow diagram, MGCP agent **1206** transmits a modify connection message to MGCP gateway **1202**.

H.323 – NAQ.931 Call Hold Scenario

Figure 14 illustrates interworking between an H.323 endpoint and an NAQ.931 device for a call hold scenario. In Figure 14, it is assumed that a bi-directional media stream has been established between H.323 endpoint
5 **1200** and NAQ.931 device **1400**. H.323 endpoint **1200** can be an IP terminal, as previously described with respect to Figure 12. NAQ.931 device **1400** can comprise an IP terminal. H.323 agent **1402** includes interworking agent capabilities as well as H.323 gatekeeper capabilities. Similarly, NAQ.931 agent **1404** includes interworking agent capabilities as well as
10 NAQ.931 agent capabilities.

In line 1 of the call flow diagram, NAQ.931 device **1400** transmits a HOLD message to NAQ.931 agent **1404**. In line 2 of the call flow diagram, in response to the HOLD message, NAQ.931 agent **1404** transmits an AIP CPG message to H.323 agent **1402**. The CPG message includes the
15 connection information parameter data structure. The channel operation field in the data structure is set to mode change, and the mode field in the data structure is set to inactive. In line 3 of the call flow diagram, H.323 agent **1402** transmits a TCS = 0 message to H.323 endpoint **1200**. In line 4 of the call flow diagram, H.323 agent **1402** transmits a CLOSE LOGICAL
20 CHANNEL message to H.323 endpoint **1200**. The CLOSE LOGICAL CHANNEL message closes one of the two channels between H.323 endpoint **1200** and NAQ.931 device **1400**. In line 5 of the call flow diagram, NAQ.931 agent **1404** transmits a FACILITY message to NAQ.931 device **1400**. The FACILITY message indicates that inactive mode has been
25 entered. In line 6 of the call flow diagram, H.323 endpoint **1200** transmits a

CLOSE LOGICAL CHANNEL ACKNOWLEDGE message to H.323 agent **1402** acknowledging the closing of logical channel 1.

In lines 7 and 8 of the call flow diagram, H.323 endpoint **1200** and H.323 agent **1402** exchange H.245 CLOSE LOGICAL CHANNEL and
5 CLOSE LOGICAL CHANNEL ACKNOWLEDGE messages for logical channel 2. Once logical channel 2 is closed, in line 9 of the call flow diagram H.323 agent **1402** transmits an AIP CPG message to NAQ.931 agent **1404**. The AIP CPG message includes the connection information parameter. The change operation field in the connection information parameter data
10 structure is set to mode change, and the mode is set to inactive.

H.323 – NAQ.931 Call Retrieve Scenario

Figure 15 illustrates H.323 to NAQ.931 interworking for a call retrieve scenario. The entities illustrated in Figure 15 are the same as those illustrated in Figure 14. Hence, a description thereof is not repeated herein.
15 In Figure 15, it is assumed that a call between H.323 endpoint **1200** and NAQ.931 device **1400** has been put on hold. Thus, the signaling that must occur between H.323 endpoint **1200** and NAQ.931 device **1400** to retrieve the call includes reopening the logical channels between H.323 endpoint **1200** and NAQ.931 device **1400**.

20 In line 1 of the call flow diagram illustrated in Figure 15, NAQ.931 device **1400** transmits a RETRIEVE message to NAQ.931 agent **1404**. In line 2 of the call flow diagram, NAQ.931 agent **1404** transmits an AIP CPG message to H.323 agent **1402**. The CPG message includes the connection information parameter data structure with the change operation field set to
25 mode change and the mode set to send/receive. In lines 3 and 4 of the call

flow diagram, the H.245 master/slave determination occurs between H.323 endpoint **1200** and H.323 agent **1402**. H.323 endpoint **1200** and H.323 agent **1402** must revert to a TCS exchange in order to reestablish the media streams. Accordingly, in lines 5 and 6 of the call flow diagram H.323
5 endpoint **1200** and H.323 agent **1402** exchange TCS and TCS ACK messages.

In line 7 of the call flow diagram H.323 endpoint **1200** transmits an H.245 OPEN LOGICAL CHANNEL to H.323 agent **1402**. In line 8 of the call flow diagram, H.323 agent **1402** transmits an AIP CPG message to
10 NAQ.931 agent **1404**. The CPG message includes the connection information parameter data structure. The channel operation field and the data structure is set to mode change and the mode is set to send only. This reestablishes one of the media streams between H.323 endpoint **1200** and NAQ.931 device **1400**. In line 9 of the call flow diagram, NAQ.931 agent
15 **1404** transmits a FACILITY message to NAQ.931 device **1400**. The FACILITY message includes a mode parameter that sets the channel to be receive only.

In line 10 of the call flow diagram H.323 agent **1402** transmits an OPEN LOGICAL CHANNEL ACKNOWLEDGE message to H.323 endpoint
20 **1200** acknowledging the opening of logical channel 1. In line 11 of the call flow diagram, H.323 agent **1402** transmits an H.245 OPEN LOGICAL CHANNEL message to H.323 endpoint **1200** to open logical channel 2. In line 12 of the call flow diagram, H.323 endpoint **1200** transmits an H.245 OPEN LOGICAL CHANNEL ACKNOWLEDGE message to H.323 agent
25 **1402**. In line 13 of the call flow diagram, H.323 agent **1402** transmits an AIP

CPG message to NAQ.931 agent **1404**. The CPG message includes the connection information parameter data structure. The channel operation field in the data structure is set to mode change and the mode field is set to send/receive. In line 14 of the call flow diagram, NAQ.931 agent **1404**
5 transmits a FACILITY message to NAQ.931 device **1400**. The FACILITY message includes a mode field that sets the mode to be send/receive. Once this message is received, both logical channels are open between H.323 endpoint **1200** and NAQ.931 device **1400**.

H.323 – MGCP Hold Scenario

10 Figure 16 illustrates interworking for an H.323 – MGCP hold scenario. In Figure 16, it is assumed that a call has been established between H.323 endpoint **1200** and MGCP device **1600**. MGCP device **1600** is assumed to support an event package for call hold and retrieve events. H.323 device **1200** is the same as H.323 device **1200** described with respect to Figure 12,
15 and hence a description thereof is not repeated herein. MGCP device **1600** can be an MGCP device, such as a media gateway. MGCP agent **1602** includes interworking agent functionality as well as MGCP media gateway controller functionality. H.323 agent **1402** is the same as H.323 agent **1402** described with respect to Figure 14, and hence a description thereof is not
20 repeated herein.

In line 1 of the call flow diagram, MGCP device **1600** transmits a NOTIFY message to MGCP agent **1602**. The NOTIFY message includes an event that informs MGCP agent **1602** that the end user connected to MGCP device **1600** has placed the call on hold. In line 2 of the call flow diagram,
25 MGCP agent **1602** transmits an AIP CPG message to H.323 agent **1402**.

The AIP CPG message includes the connection information parameter. The channel operation field in the connection information parameter data structure is set to mode change and the mode field is set to inactive. In line 3 of the call flow diagram, H.323 agent **1402** transmits a TCS = 0 message to H.323 endpoint **1200**.

In lines 4 and 5 of the call flow diagram, H.323 endpoint **1200** and H.323 agent **1402** exchange CLOSE LOGICAL CHANNEL messages to close the logical channel between H.323 endpoint **1200** and MGCP device **1600**. In line 6 of the call flow diagram, MGCP agent **1602** transmits a MODIFY connection (MDCX) message to MGCP device **1600** indicating that the mode has been set to inactive. In lines 7 and 8 of the call flow diagram, H.323 endpoint **1200** and H.323 agent **1402** exchange the messaging required to close logical channel 2. H.323 agent **1402** interprets the inactive mode as a hold and applies H.323 third party calls and rerouting procedures to implement the hold actions. These procedures result in the closing of both unidirectional media streams between H.323 endpoint **1200** and MGCP device **1600**. In line 9 of the call flow diagram, H.323 agent **1402** transmits an AIP CPG message to MGCP agent **1602**. The CPG message includes the connection information parameter data structure. The channel operation field in the connection information data structure is set to mode change, and the mode field is set to inactive.

H.323 – MGCP Retrieve Scenario

Figure 17 illustrates an H.323 – MGCP retrieve scenario. The entities illustrated in Figure 17 are the same as those illustrated in Figure 16, and hence a description thereof is not repeated herein. In Figure 17, it is

In line 1 of the call flow diagram, MGCP device **1600** transmits a NOTIFY message to MGCP agent **1602**. The NOTIFY message contains an event that indicates to MGCP agent **1602** that the end user connected to MGCP device **1600** wishes to retrieve the call. In line 2 of the call flow diagram, MGCP agent **1602** transmits an AIP CPG message to H.323 agent **1402**. The AIP CPG message includes the connection information parameter data structure. The channel operation field in the data structure is set to mode change, and the mode field is set to send/receive.

In lines 3 and 4 of the call flow diagram, H.323 agent **1402** and H.323 endpoint **1200** make a master/slave determination. The H.323 devices must revert to a TCS exchange in order to reestablish the media streams. Accordingly, in lines 5 and 6 of the call flow diagram, H.323 agent **1402** and H.323 endpoint **1200** exchange terminal capabilities.

In line 7 of the call flow diagram, H.323 endpoint **1200** transmits an H.245 open logical channel message to H.323 agent **1402** to open one of the logical channels between H.323 endpoint **1200** and MGCP device **1600**. In line 8 of the call flow diagram, H.323 agent **1402** transmits an AIP CPG message to MGCP agent **1602**. The AIP CPG message includes the connection information parameter data structure. The change operation field in the data structure is set to mode change, and the mode field is set to send only. In line 9 of the call flow diagram, MGCP agent **1602** transmits a modify connection message to MGCP device **1600**. The modify connection message includes a mode field setting the mode to receive only. In line 10

of the call flow diagram H.323 agent **1402** acknowledges the H.245 open logical channel messages transmitted in line 7 of the call flow diagram.

In lines 11 and 12 of the call flow diagram, H.323 endpoint **1200** and H.323 agent **1402** exchange messaging for opening the other logical
5 channel between H.323 endpoint and MGCP device **1600**. In line 13 of the call flow diagram, H.323 agent **1402** transmits an AIP CPG message to MGCP agent **1602**. The CPG message includes the connection information parameter data structure. The channel operation field in the data structure is set to mode change, and the mode field is set to send/receive. In line 14 of
10 the call flow diagram, MGCP agent **1602** transmits a modify connection message to MGCP device **1600**. The modify connection message instructs the device to change the mode to send/receive. At this point, both media streams between H.323 endpoint **1200** and MGCP device **1600** are established.

15 H.323 to MGCP Primary Rate Interface (PRI)

Common Channel Signaling (CCS)

Figure 18 illustrates exemplary call signaling for H.323 to MGCP PRI (CCS). In Figure 18, signaling gateway **1800** relays call control signaling between a circuit-switched network and a packet-switched network. For
20 example, signaling gateway **1800** may be connected to a PSTN end office on one side and to an IP network on the other side. In the illustrated embodiment, signaling gateway **1800** is configured to forward Q.931 call signaling messages from the PSTN network to a packet network and vice-versa. On the circuit-switched side, SG **1800** can be configured to send and
25 receive Q.931 over Q.921 call signaling messages. On the packet-switched

side, signaling gateway **1800** can be configured to send and receive Q.931 over ISDN User Adaptation over TCP/IP messages.

Media gateway **1802** converts between packets and circuits to communicate the media stream to and from a PSTN end user device. On the circuit-switched side, media gateway **1802** can send and receive the media stream using pulse code modulation (PCM) voice. On the packet-switched side, media gateway **1802** can send and receive the media stream using RTP over UDP/IP. In the illustrated embodiment, media gateway **1802** is controlled using MGCP.

10 CCS agent **1804** exchanges call control information with signaling gateway **1800** and media control information with media gateway **1802**. In the illustrated embodiment, CCS **1804** communicates with signaling gateway **1800** using Q.931 call signaling over IUA over TCP/IP and with media gateway **1802** using MGCP. CCS agent **1804** also communicates with
15 H.323 agent **1806** using the agent interworking protocol, as described above. It is understood that CCS agent **1804** and H.323 agent **1806** can be part of a call server. H.323 agent **1806** and H.323 gateway **1808** exchange call signaling information according to ITU Recommendation H.225.

In line 1 of the call flow diagram, signaling gateway **1800** transmits a
20 SETUP message to CCS agent **1804**. The SETUP message includes information, such as the dialed digits for creating a call with the called party. In line 2 of the call flow diagram CCS agent **1804** transmits a CALL PROCEEDING message to signaling gateway **1800** to indicate that CCS agent **1804** is attempting to establish a call with the called party. In line 3 of
25 the call flow diagram, CCS agent **1804** sends an MGCP CREATE

In line 10 of the call flow diagram, CCS agent **1804** transmits an MGCP MODIFY CONNECTION message specifying the mode of the connection as receive only and including the media description of H.323 gateway **1808**. In line 11 of the call flow diagram, media gateway **1802** acknowledges the MODIFY CONNECTION message.

In line 12 of the call flow diagram, when the called party answers the
25 call, H.323 gateway **1808** transmits a CONNECT message to H.323 agent

1806. In line 13 of the call flow diagram, in response to receiving the CONNECT message, H.323 agent 1806 transmits an AIP ANSWER message to CCS agent 1804. In line 14 of the call flow diagram, CCS agent 1804 transmits a CONNECT message to signaling gateway 1800 indicating
5 that the call has been answered. In line 15 of the call flow diagram, CCS agent 1804 transmits a MODIFY CONNECTION message to media gateway 1802 opening the connection as send/receive. In line 16 of the call flow diagram, media gateway 1802 acknowledges the MODIFY CONNECTION message. At this point, a bi-directional media stream communication is
10 established between the called and calling parties. Thus, the call flow diagram illustrated in Figure 18 embodies the true MGCP reference architecture whereby the SG and MG are separate entities.

MGCP-H.323 Call Setup and Exchange of DTMF Digits

15 Figure 19 illustrates call signaling and exchange of DTMF digits between an MGCP gateway and an H.323 gateway. The entities illustrated in Figure 19 are the same as those illustrated in Figure 16. Hence, a description thereof is not repeated herein.

In Figure 19 it is assumed that a connection has already been
20 established between H.323 endpoint 1200 and MGCP device 1600. Therefore, call setup and teardown messages are not shown.

In line 1 of the call flow diagram, H.323 endpoint 1200 transmits a user input indication message to H.323 agent 1402 that includes the DTMF digit * encoded in the message. In line 2 of the call flow diagram, H.323
25 agent 1906 transmits an AIP_INFO message to MGCP agent 1602 that



5 CONNECTION message to MGCP device **1600**. The modify connection message includes a signal indicating the DTMF digit *. In line 4 of the call flow diagram, MGCP device **1600** acknowledges the modify connection message.

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at

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